Virtual Displays in Acceleration Environments

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The objective of this project is to develop an understanding of the spatial perceptions and motor responses produced when virtual environments (VEs) are experienced by humans in dynamically changing and constantly maintained linear and angular acceleration environments, such as occur onboard a number of specialized military vehicles. The resulting improvements to the man-machine-interfaces of aircraft, remotely piloted vehicles, tanks and simulators will improve training, increase mission effectiveness, and reduce costly mishaps. To understand the military impact of VE, it is essential to study the integration of visual and vestibular information during vehicle motion. We will do this in a series of experiments, briefly outlined below.

The first two experiments involve studies of VE effects during angular acceleration, such as would occur onboard a centrifuge-based flight simulator. The next three experiments involve studies of VE effects during linear acceleration, such as would occur onboard a centrifuge-based simulator or during high performance flight. In experiment A, we will characterize the conditions whereby head movements during angular acceleration produce motion sickness and spatial disorientation. We will develop techniques to reduce these unwanted symptoms when viewing wide visual displays and during interaction with VE. In experiment B, we will investigate the extent to which people can clearly see visual targets (like real or virtual instrument displays) during angular acceleration. We will measure the suppression of vestibular reflexes required to fixate visual targets under these circumstances, and measure symptoms of motion sickness that may arise as results of this suppression. In experiments C, D, and E, we will look at visual-vestibular integration during constant linear accelerations of 1.5 and 2g in flight, as well as constant acceleration at 2g and 3g onboard a centrifuge. We subsequently intend to evaluate the effects of dynamically varying g forces induced by changes in linear acceleration onboard a research elevator. When the high-speed rotation device is completed, we will determine the feasibility of using linear oscillation in conjunction with rotation as a measure of individual otolith function. When the visual-vestibular sphere device (shown in the figure) is completed, pilot studies will be conducted to determine the effects of background motion on the ability to track targets in foreground. Secondarily, the sphere will be used to compare the vection reduction of commercially available VR displays to real-world motion, and a three-dimensional sound display will be used to examine the individual variability of illusory motion in angular acceleration environments.

Accomplishments: (1) A series of 70 subjects was completed in which we examined the effects of gaze direction on the human linear and angular vestibulo-ocular reflexes during centrifugation. (2) Following the F-14 mishap in Nashville, the mishap board requested that we simulate the mishap using data from this workunit and other projects to predict the pilot's perception. The results were presented by CNO Admiral Bowder to the Vice President. This same material was used by VCNO Admiral Johnson in his presentation to the House National Security Committee on 16 April 1996.